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EXPERIMENTS WITH CROPS UNDER FALL IRRIGATION AT THE SCOTTSBLUFF RECLAMATION PROJECT EXPERIMENT FARM.[1]

By Fritz Knorr,
Farm Superintendent, Office of Western Irrigation Agriculture.

INTRODUCTION.

In western Nebraska, as in many other portions of the Great Plains area, precipitation during the fall and winter months is comparatively light. In these sections the major portion of the rainfall of the year occurs from April to October. As a rule, the precipitation occurring between October and April comes as light showers or as light snowfalls. As a result of this condition, it is very commonly found that land which has produced a crop the preceding year contains very little moisture at planting time in the spring. On irrigated lands this condition is frequently unfavorable to field crops. When at planting time the soil contains insufficient moisture to germinate the seed and to support the early growth of the crop, it is necessary to irrigate early in the spring. Early spring irrigation may be objectionable for three reasons: (1) It is frequently difficult to secure irrigation water as early as it is needed; (2) when it is necessary to irrigate the land but a short time before crops are planted, it is difficult, and sometimes impossible, to secure satisfactory moisture conditions in the lower depths of soil, not only in the spring but during the greater part of the season; and (3) early spring irrigation may so saturate the surface layers of soil as to delay seriously the planting of the crop.

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[1] The Scottsbluff Experiment Farm is located on the North Platte Reclamation Project, 6 miles east of Mitchell and about 8 miles northwest of Scottsbluff, Nebr. The tract consists of 160 acres of land irrigated from the Government canal. Though the entire tract is irrigable, about 30 acres are devoted to dry-land experiments. The land was withdrawn from entry by the Department of the Interior for use as an experiment farm, and operations were begun in 1909. Three of the original buildings were erected by that department. The farm is under a superintendent detailed by the Office of Western Irrigation Agriculture. The work is supported by Federal appropriation through the United States Department of Agriculture and by State appropriation through the University of Nebraska. The buildings on the farm outside of the original three structures have been erected from State funds.

Note.—The results of a 3-year experiment reported in this bulletin indicate that fall irrigation in the irrigated sections of the Great Plains area produces an increase in yield of field crops more than compensating for the cost.

Several years ago it was suggested that the soil-moisture conditions in sections where the winter precipitation was light might be very much improved if the soil was saturated with irrigation water after the crop was removed in the fall. It seemed likely that an application of water at this time would afford an opportunity for establishing satisfactory moisture conditions, not only in the surface soil but in the subsoil to a depth of 6 feet or more during the time elapsing between fall irrigation and the planting of crops the following spring. It was thought that if this were true better crops might be produced in certain irrigated sections of the Great Plains area if fall irrigation were practiced. In order to determine what effect fall irrigation would have on the crops grown, a series of experiments was started at the Scottsbluff Experiment Farm in the fall of 1910. These experiments were continued in 1911, 1912, and 1913, and three years' results are now available for consideration. An account of these experiments and the results secured is given in this bulletin.

SOIL CONDITIONS.

The surface soil at the experiment farm is a sandy loam. At depths varying from 3 to 7 feet the loam is underlain by a stratum of Brule clay varying in thickness from 1 inch to 4 inches. This clay is extremely hard when dry, but it is not highly impervious to water. Under the clay the soil to great depths consists of a very fine sand. This sand is hard when dry, but when moist it is soft and friable.

RAINFALL.

As previously stated, the rainfall in western Nebraska is comparatively light during the fall and winter months. This is indicated in detail in Table I, which shows the precipitation in inches from October, 1910, to December, 1913, inclusive:

Table I.—*Precipitation in inches at the Scottsbluff Experiment Farm from October, 1910, to December, 1913, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1910	......	......	......	......	......	......	......	......	......	0.31	0.05	0.28	....
1911	0.45	0.10	0	2.31	0.81	2.13	1.28	0.65	2.14	1.10	.08	.34	11.39
1912	.20	.60	1.27	3.72	1.66	1.61	2.45	2.77	2.70	1.16	.37	0	18.51
1913	0	0	.60	.13	3.72	1.71	1.30	4.33	1.18	.47	.11	.8	13.75

Table I shows that the total annual precipitation at the Scottsbluff Experiment Farm was 11.39 inches in 1911, 18.51 inches in 1912, and 13.75 inches in 1913. The average annual rainfall of the three years was 14.55 inches. The chief feature of the rainfall in connection with the fall-irrigation experiments is the quantity of precipitation which came during the autumn and winter months each year preceding the growing seasons of 1911, 1912, and 1913, when the crops used in these experiments were grown. The total precipitation from October 1, 1910, to April 1, 1911, amounted to 1.19 inches. From October 1, 1911, to April 1, 1912, the total precipitation was 3.59 inches, and from October 1, 1912, to April 1, 1913, it was 2.13 inches. The average total rainfall for this 6-months period during the three years was 2.3 inches, or a little less than 16 per cent of the average total annual rainfall during 1911, 1912, and 1913.

The above facts substantiate the statement previously made in connection with the low precipitation of the fall and winter months. Since much of this precipitation comes as small showers or as light snowfalls, a large proportion of the moisture is lost by evaporation from the surface soil, so that during the months from October to March, inclusive, comparatively little moisture is added to the soil by precipitation. This being true, soil which has given up the greater part of its available moisture to a field crop remains comparatively dry during the following winter.

The precipitation which came during the growing season of 1911, 1912, and 1913 could not be expected to influence greatly the results obtained with fall irrigation, since it fell on all the plats in the experiment and since irrigation water was applied uniformly to all the plats during the growing season. The chief point to be considered in connection with the rainfall as it affected the results of these experiments is that the fall and winter period was comparatively dry, the precipitation being insufficient to increase materially the quantity of moisture in the soil, particularly at depths of a foot or two below the surface.

METHODS OF EXPERIMENT.

Of the land used for these experiments one half was irrigated in the fall each year, and the other half was not so irrigated. In the fall irrigation, water was applied copiously to the soil, so as to saturate the latter to as great a depth as possible. This water was applied late in September or early in October each year, usually between September 15 and 30. In the fall of 1910 the land to be fall irrigated was plowed before irrigation, but it was found that this method necessitated considerable extra labor. In order to irrigate after plowing, the land had to be leveled, and after irrigation it was necessary to harrow the land in order to check evaporation. If irrigation water were applied before plowing, the leveling could be dispensed with. For this reason, in the fall of 1911 and again in the fall of 1912 the land was irrigated before plowing.

In the spring of each year crops were planted on the fall-irrigated land, and the same crops were planted on adjacent land not so irrigated. The spring and summer treatment of the land and crops was identical in both cases. Each crop was planted on the same date on both the fall-irrigated land and the land not so irrigated, and the irrigation during the growing season was uniform in both cases.

Irrigation was applied to the plats in both series by the usual methods. The potatoes, sugar beets, and corn were irrigated by means of furrows between the rows and the grain crops were irrigated by the field-flooding method. The water applied to the different plats was not measured, but irrigation was practiced in the way it is commonly done by good farmers in the locality. The water was allowed to flow over each plat so long as the soil absorbed it readily. In 1911, the only year in which soil-moisture determinations were made, it was found that at the first irrigation, June 10, the soil on the fall-irrigated land, Series VI, absorbed the irrigation water very readily. The soil was saturated to a depth of about 18 inches, and a good supply of water penetrated to a depth of 6 feet. Series VII, which was not fall irrigated, required a longer run of water in order to saturate the upper 18 inches of soil, and when this was done dry soil was found at a depth of 24 inches. After several attempts to apply additional water to Series VII and thus put moisture in the lower depths, the loss of water by run-off was so great that the flow had to be stopped. The results of the moisture studies made in 1911 are discussed later in this bulletin.

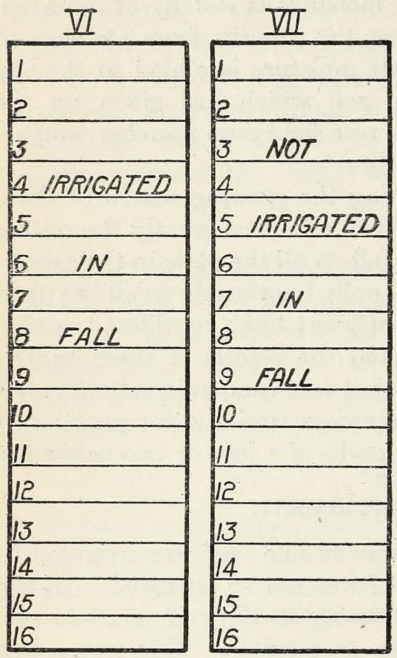

FIG. 1.—Diagram of Series VI and VII on field H, Scottsbluff Experiment Farm, where the experiments in fall irrigation were conducted.

The crops used in these experiments were wheat, barley, oats, potatoes, sugar beets, and corn. Corn was not included, however, until 1912, and only two years' results with this crop are available.

The experiments were conducted in field H, Series VI and VII, shown in figure 1. Series VI was fall irrigated each year and Series VII received no fall irrigation. The plats used were one-tenth acre in size. In 1911 there were on each of the series three plats each of wheat, barley, oats, potatoes, and sugar beets. In 1912 each series contained two plats of potatoes, two plats of corn, and three plats each of the four other crops. In 1913 there were on each series two plats of barley, two plats of potatoes, and three plats of each of the four other crops.

No attempt was made to conduct these experiments in definitely established crop rotations. The principal feature in the sequence of crops from year to year was that in most cases a cultivated crop followed an uncultivated one. For example, plat 2 in each series grew wheat in 1911, corn in 1912, and oats in 1913; and plat 11 in each series grew beets in 1911, wheat in 1912, and corn in 1913. The field on which these experiments were conducted was broken in the spring of 1910, so that all of the crops grown in 1911 were produced on virgin soil. The sequence of crops on the plats in both series during the years 1911, 1912, and 1913 is shown in Table II. Exactly the same sequence was used in Series VI as was used in Series VII; that is to say, for any given plat in Series VI in any one of the three years the corresponding plat in Series VII in the same year was planted to the same crop.

TABLE II.—*Sequence of crops in the plats in Series VI and VII, used for the fall-irrigation experiments at the Scottsbluff Experiment Farm in 1911, 1912, and 1913.*

Plat No.	Year and crop.			Plat No.	Year and crop.		
	1911	1912	1913		1911	1912	1913
1		Potatoes	Barley.	9	Oats	Barley	Beets.
2	Wheat	Corn	Oats.	10	Potatoes	Oats	Potatoes.
3	Barley	Beets	Wheat.	11	Beets	Wheat	Corn.
4	Oats	Barley	Beets.[1]	12	Wheat	Potatoes	Oats.[1]
5	Potatoes	Wheat	Potatoes.	13	Oats	Beets	Wheat.[1]
6	Beets	Oats	Corn.	14	Potatoes	Barley	Beets.
7	Wheat	Corn	Oats.	15	Barley	Oats	Corn.[1]
8	Barley	Beets	Wheat.	16	Beets	Wheat	Barley.

[1] These plats were used for a special experiment in 1913, and the yields of the crops are not considered in this report.

Table II shows that with the exception of plats 4, 9, and 15, an intertilled crop (potatoes, corn, or beets) was grown in alternation with either wheat, oats, or barley during the 3-year period.

RESULTS OF EXPERIMENTS.

A discussion of the cultural treatments applied and of the results secured in the fall-irrigation experiments during the 3-year period is given in the pages that follow.

WHEAT.

Defiance spring wheat was used in these experiments and was planted with a press drill at the rate of 6 pecks per acre each year.

In 1910 the land in both series was plowed during the first week in September. Both series were harrowed and leveled after plowing. On September 15 Series VI was irrigated. After the irrigation it seemed advisable to harrow Series VI for the purpose of checking evaporation, and in order to preserve uniformity both series were harrowed at the same time. In the spring of 1911 the land was prepared for seeding by harrowing and leveling. The wheat was seeded on March 31. On Series VII, which had not been irrigated the preceding fall, the soil was very dry at planting time in the spring of 1911 and the grain was very slow to germinate. After the rains, which came during the latter part of April, however, the grain came up promptly and a good stand was secured on both series.

The wheat plats in the two series were irrigated uniformly twice during the season of 1911. No differences were noted in the time of maturity of the wheat on the two series. The crop reached maturity on August 10.

In 1911 Series VI was irrigated on September 29 and 30. As soon as the soil was sufficiently dry in Series VI both series were plowed to a depth of about 7 inches. They were left in a rough condition during the winter. It is believed that leaving the soil in the rough condition had the effect of preventing much of the soil drifting which commonly occurs when the soil is left in a finely pulverized state during the winter months. As previously stated, the total precipitation from October 1, 1911, to April 1, 1912, was 3.59 inches, which was more than that which fell during the corresponding period in either the preceding or the following year. This relatively high precipitation left the soil on the series not irrigated in the fall in better condition at spring planting time in 1912 than at the corresponding time in 1911. When spring operations were begun in 1912, the surface soil on both series was in excellent condition for receiving the seed, and it was expected that there would be little, if any, difference in the yields obtained on the two series during that year. The two series were double-disked, harrowed, and leveled preparatory to seeding, and the wheat was planted on April 10. Uniform treatment was applied to the two series as in 1911. Both series were irrigated twice. No difference was noted in the time of maturity of the wheat on the two series. The crop on all the plats ripened August 2.

In 1912 Series VI was irrigated on September 29 and 30. As soon as the soil was sufficiently dry in Series VI both series were plowed and left in a rough condition over winter. The preparation for planting in the spring of 1913 was the same as that in 1912. The wheat was planted on April 4. The soil was in good condition at the time of planting and copious rains in April resulted in a uniform germination of the grain on all the plats. The irrigation and other treatments subsequent to planting were uniform on both series during the growing season. Both series were irrigated twice. All the wheat ripened about the same time, July 30.

The numbers of the plats, the height of the wheat at maturity, the yields of straw and of grain, and the number of pounds of straw accompanying the production of each bushel of grain during the three years are given in Table III. The plat numbers were the same in each series each year. In other words, where plats 5, 11, and 16 in Series VI were fall irrigated, the corresponding plats in Series VII grew the same crops and were otherwise treated in the same way, except that they received no fall irrigation. In studying the table it is necessary to keep this in mind and to remember that the figures in columns headed "VI" relate to the fall-irrigated plats, while those in the column headed "VII" relate to the plats which were not fall irrigated.

TABLE III.—*Results obtained with wheat on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1911, 1912, and 1913.*

Year and plat.	Height (inches).		Yield per acre.				Pounds of straw per bushel of grain.	
			Straw (pounds).		Grain (bushels).			
	VI.	VII.	VI.	VII.	VI.	VII.	VI.	VII.
1911.								
Plat 2	29	28	3,520	2,940	31.1	22.6	113.2	130.1
Plat 7	31	29	3,220	2,640	31.3	21.0	102.8	125.7
Plat 12	31	28	3,020	3,170	32.1	23.8	94.1	133.2
Average	30	28	3,253	2,916	31.5	22.4	103.3	130.2
1912.								
Plat 5	40	36	3,910	3,410	45.5	46.9	85.9	72.7
Plat 11	42	38	3,080	2,250	40.7	35.9	75.7	62.9
Plat 16	40	37	2,720	3,760	38.7	32.4	70.3	116.0
Average	40	37	3,236	3,140	41.6	38.4	77.8	81.8
1913.								
Plat 3	36	37	1,640	1,200	26 3	20.6	62.4	58.2
Plat 8	39	38	1,750	2,060	27.5	25.0	63.6	82.4
Average	37	37	1,695	1,630	26.9	22.8	63.0	71.5
Average results, three years	35.8	34.1	2,728	2,562	33.3	27.8	81.9	92.1
Difference in favor of fall irrigation	+1.7		+166		+5.5		−10.2	

Table III shows that the average results obtained with wheat during each of the three years favored fall irrigation. There were several individual instances in which the results did not agree with the average results, but the inconsistencies were in all cases relatively small. Considering the average results during each of the three years, the wheat on fall-irrigated land grew taller and produced heavier yields of straw and of grain and a lower proportion of straw to grain than the wheat on land which was not fall irrigated. Considering the average results of the 3-year period, the wheat on the fall-irrigated land grew 1.7 inches taller, produced 166 pounds more of straw, 5.5 bushels more of grain per acre, and 10.2 pounds less straw per bushel of grain than the wheat on the land which was not fall irrigated.

BARLEY.

The soil treatment applied to the plats which produced barley was substantially the same as that applied to the wheat plats during the three years. Plowing and other operations necessary in preparing the seed bed were the same on the barley plats as on the wheat plats, and fall irrigation was applied at the same time each year. A variety of barley known as California Feed was used during each of the three years, and it was seeded at the rate of 7 pecks per acre.

In the spring of 1911 the barley was planted on April 20. At this time the surface soil on both series was very dry, and very little seed germinated until after a rain of 0.35 inch which came on May 2. This rain supplied sufficient moisture to the fall-irrigated plats, but was not sufficient to germinate the grain on Series VII, where no fall irrigation had been applied. The barley on Series VII did not come up until after a heavy rain on May 15. After this rain the barley on both series grew well. The first irrigation was applied to the barley plats on both series on June 12. It was noted that the soil on Series VII absorbed moisture much less rapidly that that on Series VI and that the depth to which the irrigation water penetrated was somewhat greater on Series VI than on Series VII. The barley in both series was irrigated the second time on June 27. At this time the barley on the plats which had been fall irrigated showed the need of water much less than that on the plats on Series VI, but, in order to preserve uniformity, all plats were irrigated. The barley was irrigated twice during the season. The grain on both series matured on July 26.

In the spring of 1913 soil conditions at planting time were much more favorable than in 1911. This apparently was due to the relatively high rainfall of the preceding autumn, as was mentioned in connection with wheat. The seed was planted on April 24. The barley on both series germinated well and good stands were secured. The plats were irrigated twice during the season. The grain on both series matured July 30.

In the spring of 1912 barley was planted on both series on April 28. The soil conditions were fairly favorable. There was sufficient moisture in the soil to germinate the seed and support early growth. The plats in both series were irrigated twice during the season. The grain ripened on both series on July 28.

The numbers of the plats, the height of the barley at maturity, the yields of straw and of grain, and the number of pounds of straw accompanying the production of each bushel of grain during the three years are given in Table IV. The plat numbers were the same in each series each year. The figures in the columns headed "VI" relate to the fall-irrigated plats, while those in the columns headed "VII" relate to the plats which were not fall irrigated.

TABLE IV.—*Results obtained with barley on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1911, 1912, and 1913.*

Year and plat.	Height (inches).		Yield per acre. Straw (pounds).		Yield per acre. Grain (bushels).		Pounds of straw per bushel of grain.	
	VI.	VII.	VI.	VII.	VI.	VII.	VI.	VII.
1911.								
Plat 3	29	25	2,640	2,700	40.4	24.5	65.7	110.2
Plat 8	31	26	2,335	3,060	34.8	30.0	67.1	102.0
Plat 15	31	25	2,745	3,080	37.6	29.5	73.0	104.4
Average	30	25	2,573	2,936	37.6	28.0	68.4	104.9
1912.								
Plat 4	36	36	970	870	37.1	33.9	26.1	25.7
Plat 9	37	34	1,640	790	43.3	32.5	37.9	24.3
Plat 14	37	36	2,150	1,400	48.1	38.6	44.7	36.3
Average	37	36	1,586	1,020	42.8	35.0	37.1	29.1
1913.								
Plat 1	30	32	1,340	1,380	29.1	27.0	46.0	51.1
Plat 16	32	32	1,720	1,430	31.8	26.8	54.1	53.4
Average	31	32	1,530	1,405	30.4	26.9	50.3	52.2
Average results, three years	32.5	30.7	1,896	1,787	36.9	29.9	51.4	59.8
Difference in favor of fall irrigation	+1.8		+109		+7.0		−8.4	

Table IV shows that the average yields obtained with baleey during each of the three years were in favor of fall irrigation, and the same was true with all but one of the individual grain yields obtained. Barley on fall-irrigated land produced higher average yields of straw per acre each year, except 1911. In 1911 and 1912 the barley grew somewhat taller on the fall-irrigated land, but in 1913 the height of the matured grain was slightly greater on the land which was not fall irrigated. The average proportion of straw to grain was lower on the fall-irrigated land in 1911 and 1913 and higher in 1912. Considering the average results of the 3-year period, the barley on fall-irrigated land was 1.8 inches taller than that on land not fall irrigated, and it produced 109 pounds more of straw and 7 bushels more of grain per acre and 8.4 pounds less of straw per bushel of grain.

OATS.

The soil treatment and fall irrigation applied to the plats producing oats were the same as those applied to the plats producing wheat and barley during the 3-year period. A variety of oats known as "New Market" was used each year, and the seed was planted at the rate of 10 pecks per acre.

In 1911 the condition of the soil at planting time, April 20, was the same on the oats plats as on the barley plats, and the seed on both series was slow to germinate. The rains, which came on May 2 and May 15, however, added sufficient moisture to the soil to start a good stand on both series. The oats were irrigated twice during the season. No difference was noted in the time of maturity, the grain on all the plats having ripened on July 26.

In the spring of 1912 the soil was in excellent condition when the oats were planted on April 24, and good stands were secured on both series. The oats were irrigated twice during the season. No differences were noted between the two series until the grain began to head. From this time on the crop on the fall-irrigated plats was more vigorous than on the plats which had not been fall irrigated. The grain was ripe on both series on July 29.

In the spring of 1913 the oats on the fall-irrigated plats germinated much more promptly than those on the plats in Series VII. The germination on the plats which were not fall irrigated was very irregular, but the rains which came in the early part of May added sufficient moisture to the soil to produce satisfactory stands. The oats were irrigated twice during the season. The grain ripened about August 1 on both series.

The numbers of the plats, the height of the oats at maturity, the yields of straw and of grain, and the number of pounds of straw accompanying the production of each bushel of grain during the 3-year period are given in Table V. The plat numbers were the same in both series each year. In Table V, the figures in the columns headed "VI" relate to the fall-irrigated plats, while those in the columns headed "VII" relate to the plats which were not fall irrigated.

TABLE V.—*Results obtained with oats on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1911, 1912, and 1913.*

Year and plat.	Height (inches).		Yield per acre.				Pounds of straw per bushel of grain.	
			Straw (pounds).		Grain (bushels).			
	VI.	VII.	VI.	VII.	VI.	VII.	VI.	VII.
1911.								
Plat 4	40	40	3,380	2,610	66.2	40.3	51.1	64.8
Plat 9	40	38	3,350	3,280	62.5	53.7	53.6	61.1
Plat 13	38	36	3,790	3,640	76.8	55.0	49.3	66.2
Average	39	38	3,506	3,178	68.5	49.6	51.2	64.1
1912.								
Plat 6	41	42	2,920	2,230	65.6	55.3	44.5	40.3
Plat 10	44	44	4,920	3,630	113.0	96.0	43.5	37.8
Plat 15	42	42	4,670	3,790	105.2	94.1	44.4	40.3
Average	42	42	4,170	3,216	94.6	81.8	44.1	39.3
1913.								
Plat 2	43	42	3,000	1,910	84.3	76.5	35.6	24.9
Plat 7	45	42	3,620	2,100	101.2	97.5	35.8	21.5
Average	44	42	3,310	2,005	92.7	87.0	35.7	23.0
Average results, 3 years	41.9	40.8	3,656	3,521	83.8	72.8	43.6	48.4
Difference in favor of fall irrigation	+1.1		+135		+11.0		−4.8	

As shown in Table V, the individual yields of oats were in most cases higher on the fall-irrigated land, and the same was true with respect to the individual yields of straw. In 1911 the proportion of straw to grain was uniformly lower on fall-irrigated land than on land not fall irrigated, while the reverse was true in 1912 and 1913. Considering the average results of each year, the oats on the fall-irrigated land were taller in 1911 and 1913 and the same height in 1912; the average yield of straw per acre was higher on the fall-irrigated land in each of the three years, and the same is true with respect to the average yield of grain. Considering the average results of the 3-year period, oats on fall-irrigated land grew 1.1 inches taller, produced 135 pounds per acre more of straw, 11 bushels more of grain, and 4.8 pounds less of straw per bushel than oats on land not fall irrigated.

CORN.

Corn was included in this experiment in 1912 and 1913 only. The preparation of the land and the fall irrigation were the same as with the crops previously discussed. A local variety known as Calico corn was used. The seed was planted in rows 40 inches apart and the plants were thinned to 20 inches apart within the row.

In 1912 the corn was planted in both series on May 8. The crop was irrigated once during the season of 1912. No differences were noted as to the stage of maturity reached by the corn on the two series during the year. The crop was harvested on September 15, at which time the grain on all the plats was about 85 per cent matured.

In 1913 the corn was planted on May 19. During the period from July 7 to 12 severe hot winds prevailed and damaged the corn on both series to some extent. No differences were noted between the plats on the two series as to the damage done by the hot winds. The crop was irrigated once during the season. No differences were noted as to the stage of maturity reached before frost. The corn in both series was harvested on September 18, at which time it was practically all matured.

The numbers of the plats and the yields per acre of stover and of grain during the years 1912 and 1913 are given in Table VI.

Table VI shows that with one exception the individual grain yields of corn were higher each year on the fall-irrigated land. Considering the averages obtained in each of the two years, the yields of stover and of grain were higher on fall-irrigated land than on land not fall irrigated, and the proportion of stover to grain was lower on the fall-irrigated land. Considering the average results of the two years, the corn on fall-irrigated land produced 490 pounds per acre more of stover, 10.6 bushels per acre more of grain, and 5.4 pounds less of stover per bushel of grain than the corn on land which was not fall irrigated.

TABLE VI.—*Results obtained with corn on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1912 and 1913.*

Year and plat.	Yield per acre.				Pounds of stover per bushel of grain.	
	Stover (pounds).		Grain (bushels).			
	VI.	VII.	VI.	VII.	VI.	VII.
1912.						
Plat 2	4,400	4,650	57.2	52.7	76.9	88.2
Plat 7	3,700	3,100	47.2	44.9	78.4	69.0
Average	4,050	3,875	52.2	48.8	77.5	79.4
1913.						
Plat 6	4,000	4,100	70.0	56.4	57.1	72.7
Plat 11	4,850	3,040	62.1	40.0	78.1	76.0
Average	4,425	3,570	66.0	48.2	67.0	74.1
Average results, 2 years	4,212	3,722	59.1	48.5	71.3	76.7
Difference in favor of fall irrigation	+490		+10.6		−5.4	

SUGAR BEETS.

The soil treatment for sugar beets was the same as that previously described in connection with the other crops in this experiment. Sugar beets were planted in 1911, 1912, and 1913.

In 1911 the beets were planted on April 30. At this time the soil on Series VII, which was not fall irrigated, was so dry that none of the seeds germinated until about May 20. At this time heavy winds caused considerable soil drifting, which so damaged the crop on Series VII that the stand was reduced to such a point as to be considered a failure. It was too late to reseed, and sugar beets were therefore discarded for the year 1911.

In 1912 the beets were planted on April 27 in rows 20 inches apart, the seed being planted at the rate of 15 pounds per acre. Soil drifting again destroyed the stands, and the plats were reseeded during the second week in May. A good stand was secured from the second seeding. The beets were irrigated three times during the season.

In 1913 the beets were planted on May 20 in rows 20 inches apart, the seed being planted at the rate of 17 pounds per acre. The plants were thinned to 12 inches apart in the row. The crop was irrigated three times during the season. The numbers of the plats and the yields per acre obtained during 1912 and 1913 are stated in Table VII.

Table VII shows that the average yield of sugar beets was higher each year on the fall-irrigated land than on the land which received no fall irrigation. The average results of the two years show an increase of 1.6 tons per acre in favor of fall irrigation.

TABLE VII.—*Results obtained with sugar beets on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1912 and 1913.*

Year and plat.	Yield per acre (tons).	
	VI.	VII.
1912.		
Plat 3	13.4	13.1
Plat 8	11.0	8.6
Plat 13	12.3	12.6
Average	12.2	11.4
1913.		
Plat 9	11.2	8.3
Plat 14	11.6	9.5
Average	11.4	8.9
Average results, 2 years	12.3	10.7
Difference in favor of fall irrigation	+ 1.6	

POTATOES.

The preparation of the land for potatoes was substantially the same as that for the crops previously discussed. Early Ohio potatoes were used. The seed was planted in rows 42 inches apart, with the hills 15 inches apart in the row.

In 1911 the potatoes were planted during the second week in May. The plants came up promptly on both series and made good growth until July 3. At this time a disease known as leaf-roll attacked them and in less than two weeks the entire crop was destroyed, so that no yields were secured in 1911.

In 1912 the potatoes were planted during the second week in May. At the time of planting, the surface soil contained an abundance of moisture and an excellent stand was secured on both series. During the growing season no important differences were apparent between the two series. The crop was irrigated three times during the season.

In 1913 the potatoes were planted on May 30. Good stands were secured and no differences in the growth of the vines on the two series were noted during the season. The plats in both series were irrigated uniformly twice during the season. The numbers of the plats and the yields per acre in 1912 and 1913 are stated in Table VIII.

As shown in Table VIII, no important differences, either in the individual yields or in the average yields, were obtained with potatoes. Considering the average results obtained during each of the two years, the yields were slightly higher on the fall-irrigated land, but the differences were insignificant.

TABLE VIII.—*Results obtained with potatoes on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm in 1912 and 1913.*

Year and plat.	Yield per acre (bushels).	
	VI.	VII.
1912.		
Plat 1	120.0	118.0
Plat 12	122.0	121.0
Average	121.0	119.5
1913.		
Plat 5	137.0	129.0
Plat 10	120.0	121.0
Average	128.0	125.0
Average results, 2 years	124.5	122.2
Difference in favor of fall irrigation	+2.3	

SUMMARY OF ALL CROPS.

The more important figures previously given in connection with the six crops included in the experiment are briefly summarized in Table IX. This table states the number of years results have been secured with each crop, the number of plats which have been devoted to each crop during the period, the average yields of potatoes and sugar beets, and the average grain yields of the grain crops. The differences in favor of fall irrigation are also stated. In order to show the relative effect of fall irrigation on the six different crops, the yields given in the first part of the table are stated in percentages in the last three columns, where the yields obtained on the land which was not fall irrigated are considered as 100 per cent in each case. As in the preceding tables, the figures in the columns headed "VI" relate to fall-irrigated land and those in the columns headed "VII" relate to the land which received no fall irrigation.

TABLE IX.—*Average and relative yields of six crops on fall-irrigated land (Series VI) and on land not fall irrigated (Series VII) at the Scottsbluff Experiment Farm.*

Crop.	Number of years.	Number of plats.		Unit of yield.	Average yield per acre.			Relative yield per acre (per cent).		
		VI.	VII.		VI.	VII.	Gain by fall irrigation.	VI.	VII.	Gain by fall irrigation.
Wheat	3	8	8	Bushel	33.3	27.8	5.5	119	100	19
Barley	3	8	8	...do	36.9	29.9	7.0	123	100	23
Oats	3	8	8	...do	83.8	72.8	11.0	115	100	15
Corn	2	4	4	...do	59.1	48.5	10.6	122	100	22
Sugar beets	2	5	5	Ton	12.3	10.7	1.6	115	100	15
Potatoes	2	4	4	Bushel	124.5	122.2	2.3	102	100	2
All crops								116	100	16

As shown in Table IX, the average yields of all six crops were higher on fall-irrigated land than on land which was not fall irrigated, the average increase having been 16 per cent.

SOIL-MOISTURE STUDIES.

The soil-moisture conditions on the three wheat plats in each series were studied during the season of 1911. A 6-foot boring was taken from each of the three plats in each series seven times during that season, and the moisture content of each 1-foot section of soil was determined. The wheat plats on both series were irrigated twice during the season of 1911, on June 10 and July 5 and 6, and the plats in Series VI had been irrigated in the fall of 1910, as previously stated.

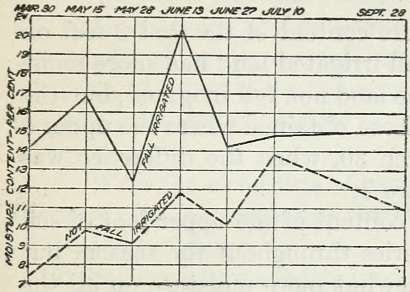

FIG. 2.—Average moisture content of soil to a depth of 6 feet on three wheat plats on fall-irrigated land and three wheat plats on land not fall irrigated at the Scottsbluff Experiment Farm, 1911.

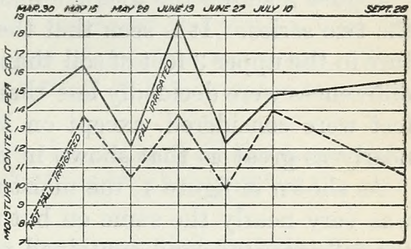

FIG. 3.—Average moisture content of soil to a depth of 3 feet on three wheat plats on fall-irrigated land and three wheat plats on land not fall irrigated at the Scottsbluff Experiment Farm, 1911.

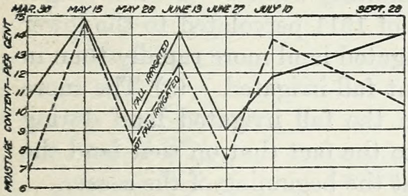

FIG. 4.—Average moisture content of surface foot of soil on three wheat plats on fall-irrigated land and on three wheat plats on land not fall irrigated at the Scottsbluff Experiment Farm, 1911.

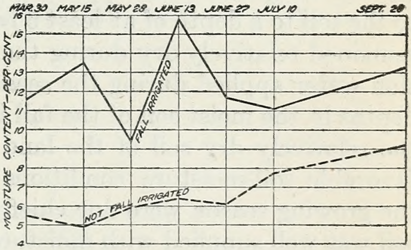

FIG. 5.—Average moisture content of the sixth foot of soil on three wheat plats on fall-irrigated land and on three wheat plats on land not fall irrigated at the Scottsbluff Experiment Farm, 1911.

The moisture content of the soil on the seven sampling dates is shown in figures 2, 3, 4, and 5. The average moisture content of the first 6 feet is shown in figure 2 and that of the first 3 feet in figure 3, while figures 4 and 5 show the moisture content of the first foot and sixth foot, respectively.

As shown in figure 2, the average moisture content of the first 6 feet of soil was higher throughout the season on the fall-irrigated land than on the land that was not fall irrigated. The difference was about 7 per cent on March 30 and May 15, about 3 per cent on May 28, more than 8 per cent on June 13, 4 per cent on June 27, 1 per cent on July 10, and 4 per cent on September 28. That these differences in the average moisture content of the first 6 feet were due mainly to the relative dryness of the lower portion of the 6-foot zone of soil on the land not fall irrigated can be seen by an examination of figures 3, 4, and 5.

Figure 3 shows the average moisture content of the first 3 feet on the two series. It is seen that the fall-irrigated land had more moisture in the upper 3 feet of soil than the land not fall irrigated, but the differences were decidedly less than those obtained where the upper 6 feet were considered, except on March 30, when the difference was nearly as great as that shown in figure 2.

As shown in figure 4, the moisture content of the upper foot of soil was very nearly the same on both series throughout the season, but the fall-irrigated land contained somewhat more moisture on all the sampling dates except July 10.

Figure 5 shows the moisture content of the sixth foot of soil during the season of 1911. It is seen that the sixth foot of soil on the land not fall irrigated was comparatively dry throughout the season. It contained about 5 per cent of moisture on March 30, and this moisture content increased to about 9 per cent by September 28. The sixth foot of soil on the fall-irrigated land contained nearly 12 per cent of moisture on March 30, and about the same on September 28.

A study of these four figures leads to the following conclusions: (1) The irrigation water applied in the fall supplied abundant moisture to the soil to a depth of at least 6 feet, while the land not fall irrigated remained relatively dry during the following winter. (2) The irrigation water applied during the season of 1911 percolated to the lower depths in the moist soil of the fall irrigated land more rapidly than in the relatively dry soil of the land not fall-irrigated. (3) The more favorable soil-moisture conditions on the fall irrigated land during the growing season were due chiefly to the fact that on that land the soil was well supplied with moisture at the beginning of the season.

SUMMARY.

(1) In many sections of the Great Plains area a comparatively small proportion of the annual precipitation comes during the period from October to March, inclusive, and the result is that the soil is frequently too dry at planting time in the spring to promote germination and support an early growth of spring-planted crops.

(2) Experiments were started in the fall of 1910 at the Scottsbluff Experiment Farm to determine whether fall irrigation of the land would improve the soil-moisture conditions and result in better yields of field crops.

(3) These experiments included wheat, oats, barley, potatoes, sugar beets, and corn. Three years' results have been obtained with wheat, oats, and barley, and two years' results with potatoes, sugar beets, and corn.

(4) With very few exceptions, higher yields of each crop were obtained each year from the land which was fall irrigated than from adjacent land which was not fall irrigated. Considering the average results of three years, fall irrigation increased the yield of wheat 19 per cent, of barley 23 per cent, and of oats 15 per cent. In the average results of two years, fall irrigation increased the yield of corn 22 per cent, of sugar beets 15 per cent, and of potatoes 2 per cent. The average increase in the yield of the six crops on fall-irrigated land was 16 per cent.

(5) With the exception of potatoes, the yields of all the crops were increased by fall irrigation sufficiently to more than pay for the cost of the fall irrigation.

(6) Soil-moisture studies made on the wheat plats in 1911 showed that the fall-irrigated land contained more soil moisture to a depth of 6 feet throughout the season than the land not fall irrigated. The greatest differences in soil moisture were found in the lower depths of soil, particularly the sixth foot, which contained from 3 to 9 per cent more moisture on the fall-irrigated land than on the land not fall irrigated.

(7) The difference in soil-moisture content during the growing season appears to have been due to the fact that the land which was not fall irrigated was comparatively dry at planting time in the spring and that it consequently absorbed water less readily than the fall-irrigated land, which was well supplied with moisture at the beginning of the season.

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